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Residential mobility during pregnancy in Urban Gansu, China

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Abstract

Background: Studies on environmental exposures during pregnancy commonly use maternal residence at time of delivery, which may result in exposure misclassification and biased estimates of exposure and disease association. Studies on residential mobility during pregnancy are needed in various populations to aid studies of the environmental exposure and birth outcomes. However, there is still a lack of studies investigating residential mobility patterns in Asian populations.

Methods: We analyzed data from 10,542 pregnant women enrolled in a birth cohort study in Lanzhou, China (2010–2012), a major industrial city. Multivariate logistic regression was used to evaluate residential mobility patterns in relation to maternal complications and birth outcomes.

Results: Of the participants, 546 (5.2%) moved during pregnancy; among those who moved, 40.5%, 34.8%, and 24.7% moved during the first, second, and third trimester, respectively. Most movers (97.3%) moved once with a mean distance of 3.75 km (range: 1–109 km). More than half (66.1%) of the movers moved within 3 km, 13.9% moved 3–10 km, and 20.0% moved > 10 km. Pregnant women who were > 30 years or multiparous, or who had maternal complications were less likely to have moved during pregnancy. In addition, movers were less likely to deliver infants with birth defects, preterm births, and low birth weight.

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Author contributions
Jie Qiu, Qing Liu, and Yawei Zhang conceived and led the study; Min Zhou, Hongmei Cui, Sufen Liu, Ling Lv, Ya Chen, Ru Lin, Tingting Yao, Chong Zhang, Yun Dang, Xudong Han, and Ruifeng Xu conducted the birth cohort study; Huang Huang, Nan Zhao, Jiaxin Liang, Jiajun Luo, Min Jiang, Weitao Qiu, Zhongfeng Tang, Hanru Zhang, Haiya Bai, Daling Zhu, Xiaojuan Lin, Jie Su, Xiaoying Xu, Xiaohui Liu, Wendi Wang, Yueyuan Wang, and Bin Ma performed statistical analysis; Jie Qiu, Nan Zhao, Catherine Lerro, Qing Liu, Michelle L. Bell, and Yawei Zhang drafted and revised the manuscript; and all authors reviewed and approved the manuscript.
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Declaration of potential conflicts of interest
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Conclusions: Residential mobility was significantly associated with several maternal characteristics and complications during pregnancy. The study also showed a lower likelihood of adverse birth outcomes among movers than non-movers, suggesting that moving might be related to reduce exposure to environmental hazards. These results confirm the hypothesis that residential mobility may be important with respect to exposure misclassification and that this misclassification may vary by subpopulations.

Keywords

Residential mobility; Birth outcomes; Birth cohort; Gansu; China

1. Introduction

Studies examining the effect of environmental exposures on perinatal outcomes often rely on maternal residence at the time of delivery as a means of capturing the geographic location where women experience environmental exposures during pregnancy (Brauer et al., 2008; Bell and Belanger, 2012). This method has been used to assign such diverse environmental exposures as ambient air pollution (Brauer et al., 2008; Wilhelm, Ghosh et al., 2011; van den Hooven et al., 2012), water pollution (Winchester et al., 2009), heavy metals (Ahern et al., 2011), and chemicals (Langlois et al., 2009; Gemmill et al., 2013). Because information on where women reside at conception and during pregnancy prior to delivery is rarely available, such as in the commonly used birth certificate registries, researchers often use residential address at delivery as a proxy to determine environmental exposures during the entire pregnancy. Other methods of assessing environmental exposures, such as personal or household monitors and detailed diaries of geographic location, are often not feasible for studies due to the high costs of large cohorts.

The use of maternal residence at time of delivery as a proxy for environmental exposure throughout pregnancy may result in exposure misclassification and biased estimates of exposure and disease association (Miller et al., 2009; Bell and Belanger, 2012). Thus, understanding residential mobility of pregnant women is important for studies of environmental exposures and birth outcomes. The timing, frequency, and distance of movements would affect the extent of exposure misclassification (Bell and Belanger, 2012). Moving at later stage of pregnancy may lead to a larger degree of misclassification as compared to moving at earlier stage of pregnancy as studies often base exposure on residence at birth. A high frequency of moves (i.e., multiple moves during pregnancy) could be associated with elevated exposure misclassification. Although movements within short distances generally do not cause significant exposure misclassification, the misclassification could be substantial if the environmental pollutants having large spatial heterogeneity (Peng and Bell, 2010). The exposure misclassification could be differential if some segments of the study population have different moving patterns (e.g., are more likely to move than others) (Bentham, 1988; Bell and Belanger, 2012). The exposure misclassification could also be non-differential, potentially due to a short distance movement or very few people having moved in the study populations (Lupo et al., 2010; Chen et al., 2010). For these reasons, evidence on which subpopulations of pregnant women move during pregnancy and how moving patterns may differ is a critical research need.

Few studies have evaluated residential mobility during pregnancy, and these studies have only been conducted in European and North American populations (Khoury et al., 1988; GM and LH, 1992; Fell et al., 2004; Canfield et al., 2006; Hodgson et al., 2009; Chen et al., 2010; Lupo et al., 2010; Madsen et al., 2010; Tunstall et al., 2010). A similar pattern of residential mobility for both mothers who had neonates with adverse birth outcomes and mothers who delivered healthy babies was reported by several studies based on univariate analysis (GM and LH, 1992; Canfield et al., 2006; Lupo et al., 2010; Madsen et al., 2010). Maternal characteristics, including age, income, education, race, body mass index (BMI), and smoking, have been linked to residential mobility during pregnancy (Khoury et al., 1988; GM and LH, 1992; Fell et al., 2004; Canfield et al., 2006; Miller et al., 2009; Tunstall et al., 2010), indicating that residential mobility during pregnancy can differ by subpopulation characteristics that may influence associations between environmental exposures and birth outcomes.

Given the knowledge gap of residential mobility during pregnancy in Asian population and the lack of study investigating residential mobility patterns in relation to maternal complications, we analyzed data from a birth cohort in Lanzhou, China to examine the patterns of residential mobility during pregnancy, predictors of residential mobility, and potential relationship between residential mobility and birth outcomes.

2. Material and methods

2.1. Data collection

The cohort study design and data collection procedures have been described previously (Qiu et al., 2014). Briefly, a birth cohort was enrolled from February 2010 to December 2012 at the Gansu Provincial Maternity and Child Care Hospital (GPMCCH), the largest maternity and child care hospital in Lanzhou, Gansu, China. The 14,591 pregnant women who gave birth at the GPMCCH during this time period were eligible. A total of 10,542 women participated in the study (72% participation rate).

All study procedures were approved by the Human Investigation Committees at the GPMCCH and Yale University. Upon receiving signed consent from all participating women, an in-person interview was conducted by trained interviewers using a standardized structured questionnaire at the hospital. The questionnaire contained information on demographics, reproductive and medical history, smoking, alcohol consumption, physical activity, occupational and residential history, and dietary intake. Information on birth outcomes and maternal complications were abstracted from medical records.

Although the term “mobility” often refers to any change of permanent address (Douglas et al., 2005), here we use it to mean change of address at least once during the period from last menstrual period through delivery. Any woman with residential mobility during this time was considered to be a “mover”. The data does not include information on the reason for the move or whether the move was permanent. The weeks of gestation at the time of the move were estimated as weeks between the date of last menstrual period and the date of move. The self-reported date of last menstrual period was verified by ultrasound measurement.

First trimester was defined as weeks 1–12, second as weeks 13–27, and third from week 28 to delivery.

Maternal residential history, which included all addresses where the pregnant women lived during pregnancy, were collected from in-person interviews and were geocoded based on the Google earth engine (earthengine.google.com). Longitude and latitude coordinates were obtained for each subject's home addresses. The distance moved was defined as distance between current home address and previous home addresses and was calculated by using "geodist" function in SAS based on Vincenty's formulae (Vincenty, 1975).

Maternal covariates included age (< 25 years, 25–30 years, > 30 years), education level (≤ 9 years, 10–15 years, ≥ 16 years), employment status during pregnancy (yes/no), active and passive smoking (yes/no), parity (primiparous or multiparous), history of abortion (yes/no), and monthly household income per capita (< ¥ 1000, ¥ 1000–3000, > ¥ 3000). These characteristics were identified as predictors of residential mobility in previous studies. They are also important variables in studies of environmental exposure and birth outcomes. Complications during pregnancy were also considered, including preeclampsia, diabetes, anemia, thyroid disease, and gynecological complications (i.e., uterine abnormalities, ovarian abnormalities, infections of the vagina, cervix, uterus, and pelvic, and others). Because preeclampsia and gestational diabetes were diagnosed after 20 weeks of gestation, they were excluded from maternal complications in the analysis for those who moved in the 1st trimester. Fetus characteristics included multiple births and sex.

Birth outcomes included low birth weight, preterm birth, and birth defects. Birth defects were identified within 48 h after birth (down syndrome, polydactylia, digestive system defects, cleft palate, congenital heart defect, neural tube defect, male reproductive defects, and stillbirth). Birth weight was divided as < 2500 g, 2500–4000 g, and ≥ 4000 g (WHO, 2018). Preterm births (less than 37 completed gestational weeks) were further classified as moderate preterm (32–36 weeks) and very preterm (less than 32 weeks) (WHO, 2012).

2.2. Statistical analyses

Bivariate analyses were performed using chi-square tests for categorical variables and *t*-tests for continuous variables. Logistic regression models were used to calculate odds ratios (ORs) and 95% confidence intervals (95% CIs). Factors associated with residential mobility were evaluated using multivariate logistic regression models. The associations between residential mobility and adverse birth outcomes were also examined by multivariate logistic regression models adjusting for maternal age, education, family income, passive and active smoking, parity, history of abortion, multiple births, and maternal complications. All tests were two-sided and assessed at the 0.05 level of significance. All analyses were performed using SAS version 9.3 (SAS Institute, Cary, NC).

3. Results

Of the 10,542 women in our study, 546 (5.2%) women moved at least once during the time from last menstrual period to delivery. Among those who moved, 40.5% moved in the first trimester, 34.8% in the second trimester, and 24.7% in the third trimester. The majority of movers moved once (97.3%), with a mean distance of 3.75 km (range: 1–109 km), while 2.6% moved twice with a mean distance across two moves of 11.06 km (range: 1–21 km). One individual moved three times, with mean distance across moves of less than 1 km. Note that for mothers who moved multiple times, the distance moved is the sum of the distance between the first and second residence, the second and third residence, and if applicable the third and fourth residence, rather than the linear distance between the first and last residences. More than half (66.1%) of the movers moved within 3 km, 76 (1 3.9%) women moved between 3 and 10 km, and 109 (20.0%) women moved beyond 10km.

The distribution of maternal characteristics and birth outcomes by mobility status is presented in Table 1. Movers were more likely to be younger ($p < .0001$), primiparous ($p < .0001$), and have maternal complications ($p < .0001$). They were also less likely to give birth preterm ($p = 0.0017$) and deliver infants with birth defects ($p = 0.0089$).

Table 2 shows the association between maternal characteristics and residential mobility. Younger mothers (aged < 25 years) were more likely to move (OR: 1.60, 95% CI: 1.27–2.03) while women aged > 30 years were less likely to move (OR: 0.69, 95% CI: 0.55–0.86) compared to women aged 25–30 years old. Women who were multiparous (OR: 0.71, 95% CI: 0.56–0.89) or who had complications (OR: 0.77, 95% CI: 0.61–0.92) were less likely to move, compared to the appropriate reference categories. Maternal education, household income, employment status during pregnancy, smoking, and history of abortion were not significantly associated with mobility.

After stratifying by time of moving based on trimesters, different associations were observed by subpopulation for residential mobility during pregnancy (Table 3). For those who moved in the 1st trimester, mothers who were < 25 years old (OR: 1.74, 95% CI: 1.22–2.47) or who had a history of abortion (OR: 1.49, 95% CI: 1.04–2.14) were more likely to move, while women aged > 30 years (OR: 0.58, 95% CI: 0.41–0.83) or who were multiparity (OR: 0.70, 95% CI: 0.49–1.00) were less likely to move, compared to the appropriate reference categories. For those who moved in the 2nd trimester, only the older mothers (aged > 30 years) were significantly less likely to move (OR: 0.62, 95% CI: 0.43–0.89) compared to those age 25–30 years. For those who moved in the 3rd trimester, women who had maternal complications were less likely to move (OR: 0.49, 95% CI: 0.32–0.75) compared to those without maternal complications.

We further explored whether residential mobility was associated with adverse birth outcomes in this study population (Table 4). Movers were less likely to have infants with birth defects (OR: 0.41, 95% CI: 0.21–0.80), preterm births (all preterm, 0.61, 95% CI: 0.44–0.84; moderate preterm, OR: 0.63, 95% CI: 0.45–0.90; very preterm, OR: 0.48, 95% CI: 0.24–0.98), and low birth weight (OR: 0.68, 95% CI: 0.48–0.97), compared to the appropriate reference categories. After stratification by trimesters of move, similar patterns were observed cross different trimesters although no statistically significant associations were shown potentially due to small numbers (results not shown).

In sensitivity analyses excluding multiple movers, the observed associations remained unchanged (results not shown).

4. Discussion

Although little is known about residential mobility among pregnant women, studies in Europe and the United States have found that overall mobility rates during pregnancy range from 9% to 32%, that moves occur most frequently during the second trimester, and that residential mobility patterns during pregnancy vary by subpopulation (Bell and Belanger, 2012). In our study, about 5.2% of pregnant women in Lanzhou, China changed their residence during pregnancy. Lower mobility in our study may be attributed to geographic, economic, and societal differences between China and Western countries. Our study showed the highest frequency of moves during the first trimester, while several previous studies reported the highest mobility in the second trimester (Fell et al., 2004; Chen et al., 2010). The differences between our results and that of other studies underscore the need for studies in various locations and populations.

As reported by several previous studies (Khoury et al., 1988; Fell et al., 2004; Canfield et al., 2006; Miller et al., 2009), younger maternal age was a strong predictor of mobility in our population, even after adjustment for other important maternal characteristics. Age may be related to moving patterns as young women may be more likely to rent property, and thus be more mobile than homeowners, and may be in smaller homes and wish to expand their living space. Unfortunately, we did not collect information about whether participants owned or rented their residences. Based on data from China Household Finance Survey (CHFS), the proportion of homeowners among people < 35 years ranges from 60% to 77%, while among those > 35 years ranges from 81% to 90% (CHFS, 2011). It is also possible that older mothers with more children are less likely to move compared to younger mothers with smaller families as they have already established a family home. Many earlier studies found the highest mobility among women with fewer previous pregnancies (Fell et al., 2004; Canfield et al., 2006; Hodgson et al., 2009; Lupo et al., 2010). Consistent with earlier studies, our study also found that mothers who were multiparous were less likely to move than those who were primiparous after adjusting for age and other potential confounding factors.

This study was one of the first to explore the association between residential mobility and maternal complications or history of abortion. Women with complications were less likely to move than women without complications. This association was mainly seen for the third trimester movers. Two common maternal complications, preeclampsia and gestational diabetes, generally occur after 20 weeks of gestation, which might explain the significant findings in third trimester. These women may have been more cautious about their health conditions and opted not to move during pregnancy for this reason. Alternatively, these health conditions might affect women's physical ability to move. We also observed that history of abortion was associated with increased mobility during the first trimester but not later trimesters. These findings warrant further research in relation to subpopulation characteristics and health care. One previous study explored self-rated health and residential mobility during pregnancy and reported no association (Tunstall et al., 2010).

Various indicators of socioeconomic status and residential mobility were examined in this study. Previous research examining maternal educational attainment and residential mobility during pregnancy differed in how education was categorized, and educational systems differ by country. Thus, many results are not directly comparable. Several studies have observed lower mobility associated with increasing education (GM and LH, 1992; Fell et al., 2004; Chen et al., 2010). In China, nine years of schooling is required, and 15 years of schooling is equivalent to a college level education. In our study, we did not find a significant association between education and mobility. Previous studies have reported inconsistent findings regarding income and mobility. Two studies indicated higher mobility in lower income areas in US and Canadian populations (Fell et al., 2004; Canfield et al., 2006), while another study found contradictory results in Atlanta, US (Miller et al., 2009). Similar to a recent study in Norway (Madsen et al., 2010), we found no association between income and mobility.

We did not find a significant association between smoking status and mobility, which differed from previous studies (Canfield et al., 2006; Miller et al., 2009). This may be due to lower prevalence of active and passive smoking during pregnancy in China. Only 0.8% of women in our study are active smokers, and 19% report exposure to passive cigarette smoke. These numbers were low compared to 2002 reports from European and North American studies, in which the smoking prevalence among young women during pregnancy ranged from 13% to 25% (Cnattingius, 2002).

Previous studies have compared maternal residential mobility between mothers with infants with adverse birth outcomes (i.e., birth defects and stillbirths) and other mothers, and reported similar pattern of mobility (GM and LH, 1992; Canfield et al., 2006; Lupo et al., 2010; Madsen, Gehring et al., 2010). However, our study found that mothers who moved during pregnancy were less likely to have infants with birth defects, preterm births, or low birth weight, after controlling for potential confounding factors. Since these adverse birth outcomes have been linked to various environmental hazards (Khoury et al., 1988; Ananth, 1996; Ritz et al., 2000), our findings may also indicate a potential differential misclassification of maternal exposure to these environmental risk factors.

To the best of our knowledge, our study is the first to examine the association between mobility and birth outcomes in a Chinese population, and the study benefits from a large sample size of 10,542 pregnant women as well as detailed cohort data. Compared to previous studies based on a birth registry database, such as a recent study in Norway (Madsen et al., 2010), our cohort study used in-person interviews and collected detailed information on current address, previous addresses, maternal characteristics, and birth outcomes. All study participants were of Chinese ethnicity, minimizing differences in genetic susceptibility to maternal and neonatal diseases by ethnicity. Our data allowed calculation of the actual distance mothers moved using all (geocoded) addresses reported during pregnancy. The majority of moves were relatively short distances, similar to previous findings (Hodgson et al., 2009; Chen et al., 2010). Moves of short distances may have less impact of exposure misclassification on maternal exposure depending on the pollutant's spatial heterogeneity (Peng and Bell, 2010).

One of the main limitations of our study was that the information on maternal residences and demographics was self-reported, and may be subject to inaccurate memories and recall bias. Similar limitations have also been presented in other studies on residential mobility. Our cohort study benefits from more detailed data than studies based on birth registries. In addition, some confounding variables (e.g., maternal smoking and history of abortion) may be susceptible to social desirability bias and therefore underreported. The cohort data did not include all information of potential interest, such as whether or not the pregnancy was planned, illicit drug use, marital status, the reason for the move, or whether the move was considered temporary or permanent. Our study population was Chinese urban residents who may have different demographics and life styles compared to women living in rural areas or developed countries, thus our study results may not be generalizable to other populations. However, several findings from previous studies are consistent with ours. Studies on a range of populations and regions are needed.

In conclusion, this study suggested that maternal age, parity, history of abortion, and complications during pregnancy were associated with mobility during pregnancy and the association varied by trimester of mobility. In addition, the study showed a lower likelihood of adverse birth outcomes among movers than non-movers, suggesting that moving might be related to reduce exposure to environmental hazards. These results confirm our hypothesis that residential mobility, which is often neglected in studies on birth outcomes, may be important with respect to exposure misclassification and that this misclassification may vary by subpopulation. Our findings indicate that residential mobility should be considered in future studies that relay on residential addresses for environmental exposure assessment, and that the implications of exposure misclassification and how it differs by subpopulation be considered with respect to findings based on residence at time of birth.

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Table 1

Distribution of selected maternal characteristics and birth outcomes of study population by mobility status.

	Total (N = 10,542) *N (%)*	Movers (N = 546) *N (%)*	Non-movers (N = 9996) *N (%)*	*p-value*[1]
Maternal Characteristics				
Age (years)				
< 25	1695 (16.1)	143 (26.2)	1552 (15.5)	< .0001
25–30	5102 (48.4)	272 (49.8)	4830 (48.3)	
> 30	3745 (35.5)	131 (24.0)	3614 (36.2)	
Education (years) *				
≤ 9	623 (6.0)	29 (5.4)	594 (6.1)	0.1615
10–15	3567 (34.5)	206 (38.2)	3361 (34.3)	
≥ 16	6161 (59.5)	304 (56.4)	5857 (59.7)	
Employment during pregnancy				
No	5146 (48.8)	267 (48.9)	4879 (48.8)	0.9667
Yes	5396 (51.2)	279 (51.1)	5117 (51.2)	
Active smoking during pregnancy				
No	10,455 (99.2)	542 (99.3)	9913 (99.2)	0.8058
Yes	87 (0.8)	4 (0.7)	83 (0.8)	
Passive smoking during pregnancy				
No	8530 (80.9)	440 (80.6)	8090 (80.9)	0.8411
Yes	2012 (19.1)	106 (19.4)	1906 (19.1)	
Parity				
Primiparous	7618 (72.3)	440 (80.6)	7178 (71.8)	< .0001
Mulliparous	2924 (27.7)	110 (19.4)	2818 (28.2)	
History of abortion				
No	9168 (87.0)	467 (85.5)	8701 (87.0)	0.3063
Yes	1374 (13.0)	79 (14.5)	1295 (13.0)	
Pre-pregnancy BMI (kg/m^2) *				
≤18.5	2155 (21.2)	125 (23.3)	2030 (21.1)	0.2467
18.6–23.9	6893 (67.7)	362 (67.4)	6502 (67.8)	
≥24	1128(11.1)	50 (9.3)	1075 (11.2)	
Household income (¥ /month per capita) *				
< 1000	682 (7.2)	41 (8.2)	641 (7.1)	0.5701
1000–3000	4694 (49.2)	251 (49.9)	4443 (49.2)	
> 3000	4158 (43.6)	211 (42.0)	3947 (43.7)	
Weight gain during pregnancy (kg) *				
< 15	4016 (39.8)	222 (41.7)	3794 (39.7)	0.6644
15–18.5	2370 (23.5)	120 (22.5)	2250 (23.6)	
> 18.5	3700 (36.7)	191 (35.8)	3509 (36.7)	
Maternal complications[2]				

	Total (N = 10,542)	Movers (N = 546)	Non-movers (N = 9996)	
	N (%)	*N (%)*	*N (%)*	*p-value*[1]
No	6785 (64.4)	395 (72.3)	6390 (63.9)	< .0001
Yes	3757 (35.6)	151 (27.7)	3606 (36.1)	
Birth Outcomes				
Preterm births				
No	9260 (87.8)	503 (92.1)	8757 (87.6)	0.0017
Yes	1282 (12.2)	43 (7.9)	1239 (12.4)	
Birth defects[3]				
No	10,151 (96.3)	537 (98.4)	9614 (96.2)	0.0089
Yes	391 (3.7)	9 (1.7)	382 (3.8)	
Birth weight (g)[*]				
Mean	3223	3249	3222	0.2892
< 2500	958 (9.1)	35 (6.5)	923 (9.3)	0.0837
2500–4000	8854 (84.3)	471 (86.7)	8384 (84.2)	
≥ 4000	687 (6.5)	37 (6.8)	650 (6.5)	

[1]P-value for chi-square test for categorical variables and *t*-test for continuous variables.

[2]Included preeclampsia, diabetes, anemia, thyroid disease, previous cesarean section, and gynecological complications (i.e., uterine abnormalities, ovarian abnormalities, infections of the vagina, cervix, uterus, pelvic, and other).

[3]Included Down syndrome, polydactylia, digestive system defects, cleft, CHD, NTD, male reproductive defects, stillbirth, and multiple defects.

[*]The analysis did not account for missing data.

Table 2

Associations between maternal characteristics and residential mobility.

	Non-movers *N = 9996*	Movers *N = 546*	*OR*[1] (*95% CI*)
Maternal age (years)			
< 25	1552	143	1.60 (1.27–2.03)
25–30	4830	272	1.00
> 30	3614	131	0.69 (0.55–0.86)
Education (years)			
≤ 9	594	29	1.00
10–15	3361	206	1.14 (0.76–1.72)
≥ 16	5857	304	1.05 (0.68–1.63)
Household income (¥ /month per capita)			
< 1000	641	41	1.00
1000–3000	4443	251	0.89 (0.62–1.26)
> 3000	3947	211	0.91 (0.62–1.31)
Employment during pregnancy			
No	4879	267	1.00
Yes	5117	279	1.01 (0.84–1.22)
Active smoking during pregnancy			
No	9913	542	1.00
Yes	83	4	0.88 (0.32–2.43)
Passive smoking during pregnancy			
No	8090	440	1.00
Yes	1906	106	0.98 (0.78–1.22)
Parity			
Primiparous	7178	440	1.00
Multiparous	2818	106	0.70 (0.56–0.89)
History of abortion			
No	8701	467	1.00
Yes	1295	79	1.16 (0.89–1.47)
Maternal complications[2]			
No	6650	404	1.00
Yes	3346	142	0.77 (0.61–0.92)

[1] Adjusted for all variables listed.

[2] Included anemia, thyroid disease, previous cesarean section, and gynecological complications (i.e. uterine abnormalities, ovarian abnormalities, infections of the vagina, cervix, uterus, pelvic, and other).

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Table 3

Associations between maternal characteristics and residential mobility by time of moving.

Characteristics	1st trimester movers		2nd trimester movers		3rd trimester movers	
	N=221	*OR*[1] *(95% CI)*	*N = 190*	*OR*[1] *(95% CI)*	*N= 135*	*OR*[1] *(95% CI)*
Maternal age (years)						
< 25	67	1.74 (1.22–2.47)	46	1.43 (0.96–2.13)	30	1.61 (0.98–2.63)
25–30	109	1.00	101	1.00	62	1.00
> 30	24	0.58 (0.41–0.83)	43	0.61 (0.43–0.89)	43	1.02 (0.69–1.52)
Education (years)						
≤ 9	14	1.00	9	1.00	6	1.00
10–15	93	1.06 (0.59–1.91)	67	1.23 (0.60–2.52)	46	1.15 (0.48–2.76)
≥ 16	112	0.88 (0.47–1.66)	110	1.23 (0.58–2.62)	82	1.13 (0.45–2.83)
Household income (¥ /month per capita)						
< 1000	20	1.00	13	1.00	8	1.00
1000–3000	111	0.85 (0.52–1.40)	85	0.92 (0.50–1.69)	55	0.92 (0.43–1.97)
> 3000	73	0.71 (0.41–1.22)	81	1.06 (0.56–2.00)	57	1.07 (0.50–2.36)
Employment during pregnancy						
No	109	1.00	97	1.00	61	1.00
Yes	112	1.11 (0.82–1.49)	93	0.85 (0.62–1.16)	74	1.11 (0.77–1.62)
Active smoking during pregnancy						
No	220	1.00	190	1.00	132	1.00
Yes	1	0.52 (0.07–3.80)	0	-	3	2.92 (0.90–9.45)
Passive smoking during pregnancy						
No	172	1.00	153	1.00	115	1.00
Yes	49	1.11 (0.80–1.53)	37	1.03 (0.71–1.48)	211	0.71 (0.44–1.14)
Parity						
Primiparous	177	1.00	154	1.00	109	1.00
Multiparous	−14	0.70 (0.49–1.00)	36	0.70 (0.47–1.04)	26	0.73 (0.45–1.17)
History of abortion						
No	182	1.00	168	1.00	117	1.00
Yes	39	1.49 (1.04–2.14)	22	0.91 (0.57–1.43)	18	0.96 (0.58–1.59)

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Characteristics	**1st trimester movers**		**2nd trimester movers**		**3rd trimester movers**	
	***N*=221**	***OR*[1] (95% *CI*)**	***N* = 190**	***OR*[1] (95% *CI*)**	***N*= 135**	***OR*[1] (95% *CI*)**
Maternal complications[2]						
No	160	1.00	136	1.00	108	1.00
Yes	61	0.88 (0.65–1.20)	54	0.83 (0.60–1.15)	27	0.52 (0.34–0.81)

[1] Adjusted for all variables listed.

[2] For 1st trimester movers, maternal complications included anemia, thyroid disease, previous cesarean section, and gynecological complications (i.e. uterine abnormalities, ovarian abnormalities, infections of the vagina, cervix, uterus, pelvic, and other). For 2nd and 3rd trimester movers, maternal complications included complications mentioned above with addition of preeclampsia and gestational diabetes.

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Table 4

Associations between mobility and birth outcomes (N = 10,542).

	Movers (*N = 546*)	**Non-movers** (*N = 9996*)	**Adjusted** ***OR***[1] ***(95% CI)***
Birth defects[2]			
No	537	9614	1.00
Yes	9	382	0.41 (0.21,0.80)
Pretenn births			
No	503	8757	1.00
Yes	43	1239	0.61 (0.44–0.84)
32- < 37 wks	36	1013	0.63 (0.45–0.90)
< 32 wks	7	226	0.48 (0.24–0.98)
Birth weight (g)			
< 2500	35	923	0.68 (0.48–0.97)
2500- < 4000	471	8384	1.00
≥ 4000	37	650	1.09 (0.77–1.53)

[1]Individually adjusted for maternal age, education, household income, employment, active and passive smoking, parity, history of abortion, maternal complications, and placental anomalies.

[2]Included Down syndrome, polydactylia, digestive system defects, cleft, CHD, NTD, male reproductive defects, stillbirth, and multiple defects.